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TECHNICAL PROGRESS IN SOVIET MACHINE-TOOL BUILDING

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I. SHORT HISTORY OF DOMESTIC MACHINE-TOOL BUILDING

The Tsarist government, instead of utilizing the outstanding work of the Russian people and developing domestic machine-tool building, imported most of its machine tools from abroad, principally from Germany. Domestic plants of prerevolutionary Russia manufactured only a small quantity of the simplest equipment; the manufacture of metal-cutting machine tools was in an embryonic state. In 1913, only about 1,500 machine tools of the simplest types were manufactured in Russia.

The situation in domestic machine-tool building after the October Revolution changed completely. The party and the government exerted tireless efforts to reconstruct the machine-tool-building industry while restoring the national economy. In a short time, the few remaining machine-tool-building plants of the Tsarist epoch were reconstructed and turned over to full-time machine-tool manufacture. However, the quantity of machine tools produced by these plants could not satisfy the growing demands of the national economy.

Industrialization of the country required the creation of a powerful machine-tool-building base in the USSR. During the years of the earlier Stalin Five-Year Plans, a mighty domestic machine-tool-building industry was developed. Old plants were completely rebuilt, and the largest machine-tool-building plants in Europe were built in Moscow, Kiev, Gor'kiy, and other cities of the country.

In the third year of the First Five-Year Plan, the Krasnyy Proletariy Plant alone produced almost 1½ times as many machine tools as were produced by all the machine-tool-building plants of Tsarist Russia.

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The year 1932, the last year of the First Five-Year-Plan, represents a great victory in Soviet machine-tool building. During that year, the national economy received 19,700 machine tools, 13 times more than in 1913.

Vigorous development of the machine-tool-building industry continued in the following years. In 1933, 18,438 machine tools were produced; and in 1937, 31,250 ^{FDD Translation No 39/49, 23 June 1949, p 3, paragraph 4, gives the figure 48,400 for 1937.} In 1941, the number of machine-tool plants in operation increased 4.5 times as compared with 1932.

Along with the increase in the number of machine-tools produced, a constant improvement in the quality and variety of machine tools has taken place. Whereas during the First Five-Year Plan, 40 percent of all machine tools manufactured were lathes with overhead-belt drives, in 1937, only machine tools with individual electric drive were built. At the end of the First Five-Year Plan, 40 type-sizes of machine tools had been perfected; at the end of the Second Five-Year Plan, this number had increased to 270. All of the machine tools which had been perfected during the Second Five-Year Plan were technically advanced and at least equal to the best foreign makes of that time. In 1941, more than 500 type-sizes of machine tools had been perfected.

As early as 1934, a group of Soviet designers under the guidance of V. I. Dikushin, recent Stalin Prize winner and corresponding member of the Academy of Sciences USSR, had developed the first Soviet multispindle combination drilling and boring machines, 3 years ahead of England and 8 years ahead of Germany.

A few decades ago, all machine-building plants were equipped with only universal machine tools for manufacturing parts of the most diverse shapes and sizes. Later, as the production of single-type machines in large series developed, the utilization of universal machine tools for machining large quantities of identical parts became unsuitable. As early as the beginning of this century, in addition to universal machine tools, machine-tool-building plants started to manufacture special-purpose machine tools which could be used in manufacturing only certain specified parts. Parts were machined in large series on these machine tools, with high productivity and lower production cost.

During the Second Five-Year Plan, Soviet machine-tool builders were confronted with the task of supplying high-duty special machine tools to the rapidly growing machine-building industry which was engaged in the mass production of automobiles, tractors, agricultural machinery, and other machines. The great variety of mass-produced machines and large number of different parts created serious difficulties in setting up the production of special machine tools.

The solution of this complex problem could proceed only along the line of wide utilization of standardized units in the design of special and particularly of combination drilling and boring machines. Combination machine tools are made up of standardized assemblies, units, and parts such as power heads, spindle boxes, tables, beds, etc. Each of these components fulfills certain specified functions in a machine tool. By assembling standardized components in a definite order and adding to them a few special parts, combination machine tools are produced which can be used to machine a part from one, two, three, or four sides. Hence, anywhere from a few up to a hundred tools of all kinds, such as drills, reamers, broaches, cutters, etc., can operate simultaneously on one combination machine tool.

One combination machine tool supplants several universal machine tools. The use of combination machine tools reduces the need for highly skilled labor and decreases the working-area requirements. Utilization of tested and approved standardized units in combination machine tools greatly reduces cost, designing time, and manufacturing time of these machine tools.

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As a result of the great solicitude shown by the party and the government for the development of Soviet machine-tool building, Soviet industry prior to World War II was producing the most diverse types of machine tools necessary to the national economy.

During World War II, as few as 520 combination machine tools replaced 3,500 universal machine tools in several war plants and released more than 5,500 workers for other industrial needs.

During the war, Soviet machine-tool building mastered the production of more than 200 types of special machine tools, which permitted the organization of mass production of various items needed at the front. These machine tools have made possible the use of continuous-flow production, a great increase in labor productivity, and the freeing of a large number of workers. For de-
scription of constant-flow production, [redacted]

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II. OBJECTIVES OF MACHINE-TOOL BUILDING IN THE POSTWAR FIVE-YEAR PLAN PERIOD

In 1946, at the historic session of the Supreme Soviet USSR, the Law on the postwar Five-Year Plan was passed. Soviet machine building was confronted with the task of doubling its output in 1950 as compared with the prewar level. Even higher production increases were set by the plan for metallurgical, press, and forging equipment, locomotives, automobiles, tractors, optical-mechanical and electrical-measuring instruments, and other equipment and machines.

Special attention was devoted by the postwar Five-Year Plan to problems concerning all phases of mechanization and automatization of working processes and to the adoption of constant-flow production methods in various branches of the national economy.

Machine-tool building was faced with the huge task of restoring the war-worn machine-tool park and ensuring further technical progress in machine building.

The execution of this assignment required a sharp increase in the production of special and combination machine tools and automatic transfer machine lines. Radical changes had to be made in the design of general-purpose machine tools, and the industry had to tool up for production of heavy, small-size, and high-precision machine tools to meet the demands of all branches of Soviet industry.

III. FULFILLMENT OF THE POSTWAR FIVE-YEAR PLAN IN MACHINE-TOOL BUILDING

The basic tendencies of modern technique -- speed-up of working processes, reduction in time spent for auxiliary operations, increase in the power, durability, and reliability of machines, automatization of control of moving parts, technological soundness (tekhnologichnost'), and maximum unification of design -- are reflected in the general-purpose machine tools produced by the Soviet machine-tool-building industry.

Only a few years ago, the best models of general-purpose machine tools, such as milling machines, operated at such cutting speeds as a few dozen meters per minute. The high-speed steel-cutting tools then available to the metalworking industry did not permit higher speeds. Consequently, these tools did not

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require machine tools with higher speeds, greater rigidity, or power. The hard alloys developed in recent years by Soviet scientists have permitted Stakhanovite workers to attain cutting speeds of 1,000 and even 2,000 meters per minute in machining ferrous metals and speeds up to 10,000 meters per minute in machining light alloys. The high speeds possible with modern hard-alloy tools required a radical change in machine-tool design, primarily in power, speed, rigidity, and vibration resistance.

In addition, the decrease in time taken by the machine tool to remove chips, as a result of the increase in cutting speed, required a decrease in the time devoted to auxiliary operations.

It is clear that simply increasing the speed of cutting does not entirely solve the problems of raising labor productivity and improving equipment utilization. For example, in machining even large-series parts on lathes and milling machines, the time taken by the machine tool to remove the chips does not, as a rule, exceed 50 percent of the time required for the completion of the entire operation.

Hence, the development of domestic designs of postwar general-purpose machine tools proceeded along the following lines

1. Automatization of the separate movements, making it possible to achieve a semiautomatic cycle during which the worker is required only to insert and clamp the workpiece and start the machine.
2. Development of suitable and easy controls by maximum reduction of control units and their good placement.
3. Development of devices precisely limiting the magnitude of working strokes. This is especially important in high-speed machining because the increased speeds of movement concentrate the attention of the worker on the moment of completion of the process, sometimes making it impossible to disengage the moving parts at the proper time.
4. Automatization of rapid travel for feed and withdrawal of tools from the workpiece.
5. Automatization of changes in cutting conditions (speeds and feeds) in various surfaces.
6. Automatization of measuring and checking the size of the workpiece.
7. Automatization of workpiece loading and removal of the machined part.

Besides an increase in the productivity of machining, principles of safety and improved working conditions are incorporated into the new domestic machine-tool designs. Efforts are being made to eliminate industrial accidents, occupational diseases, and mishaps such as the catching of worker's clothing or hands in machinery, the crushing of feet by falling workpieces, wounds caused by protruding moving or stationary machine components, etc.

A great deal of attention in the design of new machine tools is devoted to questions of protection from chips. Hundreds and even thousands of meters of chips per minute are produced by cutting tools operating at high speeds. Breaking and directing these chips away from the worker are a complicated problem which can be completely solved only on certain special machine tools.

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In all new universal machine tools, Soviet technique has freed the worker from a large number of manual operations. For example, mechanization of moving parts (tables, slides, etc.) has been widely adopted, since manual drives previously caused the worker considerable fatigue. The new machine tools are also characterized by long life and a continuously operating lubricating system. There is free and easy access to electric motors and other units built into the machine's body, which require less dismantling time during repairs.

The Experimental Scientific Research Institute of Metal-Cutting Machine Tools (ENIMS) has designed the first Soviet kneeless-type milling machine; it has a 40-kilowatt motor. This machine can mill parts at a cutting speed in excess of 1,500 meters per minute. The control is fully automatic.

At the Krasnyy Proletariy Plant, the old DIP-200 lathe has been replaced by the newly designed Model 1A62 screw-cutting lathe. This lathe can machine parts 100 millimeters in diameter at a speed of 360 meters per minute and larger ones at even higher speeds.

The design of this machine tool incorporates significant improvements which facilitate high-speed work. The lathe apron has a dial for indicating machining length. To measure machining length on the old lathe, it was necessary to use a ruler and stop the lathe. The good technological features of the 1A62's design made it possible to convert its production to the constant-flow method.

The same plant has begun series production of the high-power universal, high-speed Model 1620 screw-cutting lathe, with 200-millimeter height of centers. The spindle speeds on this lathe are infinitely variable within the range of 18-3,000 revolutions per minute. Parts 100 millimeters in diameter can be machined at speeds up to 900 meters per minute. A small number of handles and buttons are conveniently located for easy machine-tool control.

The 1620 lathe excels all known foreign universal screw-cutting lathes of its size in operating qualities. For the development of this unique screw-cutting lathe, V. T. Levshunov, supervisor of the project and leading designer of the Krasnyy Proletariy Plant, and a group of the plant workers were awarded a Stalin Prize in 1950.

In 1949, series production of the new Model 1616 screw-cutting lathe, with 160-millimeter height of centers, was begun at the Volzhskiy Machine-Tool-Building Plant. The high speed, power, and rigidity of the 1616 permit the machining of parts 80 millimeters in diameter at a speed of up to 500 meters per minute. Control of this lathe is exceptional for its simplicity and convenience.

In 1949, production of the following five new models of knee-type milling machines was started at the Gor'kiy Milling-Machine Plant: the 6N82 universal, the 6N82G horizontal, the 6N12 vertical, the 6N83G horizontal, and the 6N13 vertical. These machines make possible the machining of parts at speeds of 600 meters per minute and up.

The new machines, in addition to their great power and high speed, are convenient to operate, the control being effected by means of a small number of conveniently located handles and buttons. These machines are also characterized by rapid-travel mechanical arrangements for moving the table in three directions (longitudinal, transverse, and vertical), which permit the machining to proceed in a semiautomatic cycle. The operator need only clamp and remove the workpiece and watch the operation. All remaining operations are fully automatic. The machines can also be set up for the pendulum (mayatnikovyy) automatic cycle. High speeds of cutting, and automatization of auxiliary operations ensure high productivity.

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For mastering the production of these milling machines, a group of workers at the Gor'kiy Milling-Machine Plant, headed by leading designer Petyashin, were awarded a Stalin Prize for 1949.

The [Odessa] Radial-Drilling-Machine Plant has begun series production of a new, large radial-drilling machine, Model 257. Speeds and feeds on this machine can be preselected and are changed automatically during the tool change by means of a special hydraulic mechanism joined to the chuck and to the gear shift connections. This machine also has automatic feed disengagement after drilling to a given depth.

The [Leningrad] Plant imeni Sverdlov has manufactured an experimental model of a new horizontal boring machine, Model 2631, with a spindle diameter of 125 millimeters. This machine is distinguished by its great rigidity and vibration resistance; it assures high precision and fineness of finish. The entire control system works by push buttons. There is provision for the installation of an optical unit with a screen reading of coordinates which permits the performance of precision operations in a minimum amount of time.

The postwar Five-Year Plan, which devoted great attention to an increase in labor productivity in all branches of the national economy, also pointed out that one of the basic ways to achieve this goal was the widespread introduction of special, combination, and automatic machine tools, and automatic constant-flow lines.

The basic advantage of the special and combination machine tools lies in the sharp decrease in production area and in the number of machine tools required, as well as the increase in labor productivity in the mass production of parts. This is achieved through the concentration of operations and the simultaneous use of a large number of tools. Frequently, a workpiece is machined from several sides at one time.

Work under large-series production conditions, which would require 30 lathes, 30 operators, and 250 square meters of production area, could be done on four multispindle automatic lathes attended by two workers in 60 square meters of production area.

The postwar period in the development of Soviet machine-tool building is characterized by great success in the field of perfecting special and combination machine tools and automatic-transfer machine lines.

The proportion of special and combination machine tools produced in relation to the total output of enterprises of the Ministry of Machine-Tool Building increased from 0.9 percent in 1937 to 11.2 percent in 1949. The number of such machines in 1949 was 32 times the 1937 figure.

In 1949, the Krasnyy Proletariy Plant put out a series of special high-speed lathes for chuck and center work. Models MK-163, MK-164, MK-167, MK-182, and MK-185. These lathes, set on an ordinary base, have found wide application in a number of branches of machine building. The design of these lathes provides for cutting speeds above 1,600 meters per minute. Hence, the productivity of lathe operations can be increased more than four times. An electric tracer device on these machines makes it possible to adopt new improved technology, to raise the technical level of machining complex-shaped parts with diameters up to 1,400 millimeters, and to simplify and facilitate the worker's job considerably.

The same plant has perfected a new 35-ton Model 9801 lathe for the semi-finishing and final turning of crankpins up to 450 millimeters in diameter and adjacent webs of crankshafts 5,000 millimeters long. This machine assures high precision machining of the part.

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For the first time in the Soviet Union, the Krasnyy Proletariy Plant has put out a two-position hydraulic multicutter semiautomatic, Model 1841, weighing 32 tons. It is designed for simultaneous machining of all the connecting-rod journals on two automobile crankshafts. The operator has only to clamp and remove the work and start the machine. Besides high precision machining, this lathe also ensures double productivity.

The Krasnyy Proletariy Plant has also released an original high-duty thread-milling automatic, Model MK-191. The new machine tool permits the simultaneous milling of a hole and face and the cutting of threads on both ends of a graphite electrode 225-500 millimeters in diameter and 1,500 millimeters long. Machining, loading, and unloading of workpieces on this machine are fully automatic, which assures high labor productivity and permits the simultaneous attendance of several machines by one worker. All the working parts are hermetically sealed, the cutting process taking place inside special hoods from which the graphite dust is removed by a ventilating device. This ensures sanitary and hygienic working conditions and long life of the mechanisms of the machine.

The Plant imeni Sverdlov perfected a heavy four-spindle horizontal boring machine, Model LR-10, weighing 175 tons, to be used for the simultaneous bilateral high-speed boring of the piston and valve openings of the cylinder of L-series locomotives, as well as turning the adjacent faces. The high rigidity and vibration resistance of the machine tool permit boring speeds up to 400 meters per minute and provide an increase in productivity of eight to ten times as compared with foreign-made machines. The design makes it unnecessary to use removable boring bars, which considerably eases the job of the worker and cuts down on time for auxiliary operations.

The same plant has perfected the two-spindle Model LR-15 machine tool for finish boring and facing the crank pin in the wheel pairs of Series L, SO, and SU locomotives. In comparison with similar foreign-made machines, productivity of the Soviet machine (up to ten wheel pairs per shift) is four to eight times as great, with half as many attending personnel required. For development of the domestic horizontal boring machines, M. Ye. El'yasberg, the leader of the project and chief designer of the Plant imeni Sverdlov, and a group of plant workers were awarded a Stalin Prize for 1950.

Until recently, duplicating machines of US manufacture were considered the best machine tools for machining complex surfaces. During the postwar years, T. N. Sokolov, Stalin Prize winner, in collaboration with a group of designers and engineers, designed an electric duplicating automatic which machines such complex surfaces as dies and press molds faster and more accurately than US machines of this type.

The automatic lathes for machining railroad-car and tender axles developed by personnel of the Krasnyy Proletariy Plant are widely known and used. Railroad-car axles undergo complete machining on these lathes which have a 20-percent greater productivity than comparable lathes of prominent US firms.

During World War II, a number of plants producing tank and aircraft engines were completely equipped with Soviet combination machine tools. In the postwar period, the field of application of combination machine tools expanded greatly. Where as previously, they had been produced mainly for the automobile and tractor industry, they are now being supplied in ever increasing quantities to plants of the agricultural-machine-building, electrical, transport-machine-building, and other industries.

For example, one domestic 1A285 machine tool, in constant-flow line machining of mowing-machine frames, bores two holes 61.4 millimeters in diameter and drills six holes 6.7-11 millimeters in diameter at the rate of 20 frames per hour.

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Combination milling machines are also being made from standard units. A large number of these have been manufactured, particularly for the Automobile Plant imeni Stalin, which, for example, uses the 1P319 machine tool for milling the front axles of the ZIS-150 truck.

The clearest example of the technical progress in Soviet machine-tool building is furnished by the ever-increasing use of automatic-transfer machine lines. One of the basic features characterizing advanced technique is the automatization of production by the development of automatic systems of machines, each of which "performs all the motions necessary for the machining of the raw material without human assistance and needing only to be controlled by the worker" (K. Marx, Kapital, Vol I, p 387, Gospolitizdat, 1949).

The role of automatic-transfer machine lines in the economy of the country may be judged by the fact that the labor productivity of a person attending such a line is 1,000 times the productivity of manual labor.

The first postwar automatic line was produced by machine-tool builders in 1946 for the Khar'kov Tractor Plant, which had been restored from ruins. This line consists of 14 combination machine tools, and is designed for machining the cylinder heads of tractor engines. The machines in this line are set up in pairs. Between the opposing machines, attachments for clamping the parts are installed. In the lower part of these attachments are a rod and metal sliding plates (plastiny-sklizy) which extend through the entire line.

After the part is placed on the plates and the starting button is pressed on the control panel, the metal rod begins to move, and hooking the part with its dogs, delivers it to the attachment on the first pair of machines. Here, the rod releases the blank and returns to its original position. Guide pins of the attachment then go into special openings in the blank, guiding it into the proper position in relation to the tools of the machines, where it is secured by clamps. Only after all these operations, do the tool heads rapidly advance toward the part and begin to machine it. As the last tool finishes its job, the tool heads quickly withdraw, and the clamps release the part, which is moved forward to the next pair of machines by the rod. The rod, at the same time, delivers a new workpiece to the machine pair which has just completed its job. Thus, after the first blank placed on the conveyer reaches the last or seventh pair of machines, all the machines are loaded, and all 134 tools of the line are in operation.

The entire operation of the line is automatic. All the movements of conveyer, guide pins, tools, clamps, etc., are constantly controlled by electrical and hydraulic apparatus. In case of trouble in one of the links of the line, a light flashes on in the control panel, showing which machine is in trouble, and simultaneously, the machines are stopped. Every 3.5 minutes a finished cylinder head comes off the line. The machining of this same part on universal machine tools usually took 195 minutes.

Since this first line, machine-tool builders have designed several even more improved constant-flow lines, and at present, there is hardly an automobile or a tractor plant which does not employ automatic-transfer machine lines for the machining of cylinder blocks, caps (kryshka), etc.

There is an automatic-transfer machine line consisting of machine-tool Models 1A58-1A78 for machining the cylinder blocks of diesels at the Yaroslavl' Automobile Plant. It performs the drilling, counterboring, chamfering, and cutting of threads in the top and bottom faces of the cylinder block on the blower side. Blocks being machined are transferred with dogs from one position to another by means of the rod which is actuated by a hydraulic device. In moving the workpiece from one part of the line to another, it is turned automatically. Positioning and clamping of the workpiece in all work positions are

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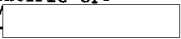
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performed pneumohydraulically. The line consists of 22 machine tools with a total of 351 spindles and 38 electric motors having a combined power of 113 kilowatts. The line is attended by four workers; its productivity is 20 blocks per hour. The production of the same number of blocks on universal machine tools would require 24 skilled workers per shift.

There is an automatic line consisting of machine-tool Models 1A443-1A448 for drilling, chamfering, facing of bosses, boring, reaming, and cutting of threads in the oblique holes in the four-cylinder engine block of the Pobeda automobile. The line consists of six inclined bilateral machines with two-position attachments, a total of 60 spindles, and 22 electric motors having a combined power of 50.8 kilowatts. The line is equipped with attachments for automatic control of hole depths, a special automatic device for centralized lubrication, and a conveyor for the removal of chips. A pneumatic chip blower is employed to clear the holes of chips prior to the cutting of threads.

The line is controlled automatically from a central control panel with devices for quick location of operational disturbances. The labor consumption in machining a block on this line is 18 times less than on universal machine tools and five times less than on combination machine tools.

An example of the high degree of automatization in the manufacturing process is furnished by the automatic plant for manufacturing aluminum pistons for the ZIS-150 and GAZ-MM trucks, which was designed by the scientific organizations and plants of the Ministry of Machine-Tool Building /  for description of this process/.

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A special place in the development of Soviet machine-tool building belongs to the production of heavy machine tools, which are necessary to a number of enterprises in such branches of industry as turbine building, ship building, excavator building, etc.

These branches of industry employ such machine tools as planing machines which machine a width and length up to 5 and 18 meters, respectively, boring mills for machining parts up to 25 meters in diameter, lathes for machining parts up to 5 meters in diameter and 30 meters long, and gear-cutting machines for cutting gears up to 12 meters in diameter. Each of these machines weighs 500 tons or more, and the power of the motors is up to 500 kilowatts. The erection of such machines requires an area of up to 500 square meters and a height of 24 meters up to the rails of the overhead traveling crane.

Soviet industry is confronted with the task of developing a domestic heavy-machine-tool-building industry capable of satisfying all the requirements of the national economy. Despite the fact that the building of such machines is a complex assignment, definite progress in the field of manufacturing heavy and large machine tools has been attained.

In 1949, the plants of the Ministry of Machine-Tool Building perfected the following universal heavy machine tools: Model 5330, a large, high-duty, gear-cutting machine, weighing 28 tons, for cutting gears 1,500 millimeters in diameter; and Model 265V boring machine with a spindle diameter of 150 millimeters, intended for boring holes up to 1,500 millimeters in diameter in the frames of large machines. This machine has a wide range of speeds and assures high-speed boring. It weighs about 70 tons. Such large boring machines are being manufactured in the USSR for the first time. Also made is the Model 7256 planing machine for planing large parts weighing up to 20 tons. Its dimensions are 2,000 x 6,000 x 1,500 millimeters. The machine has infinitely variable table speeds from 6 to 75 meters per minute. It excels all foreign-made planers of similar size in speed acceleration. It weighs about 65 tons.

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Production has also been mastered of Model 1551 universal two-sided vertical lathe for machining parts up to 1,650 millimeters in diameter. The maximum face-plate speed, which is up to 95 revolutions per minute, permits machining of work 1,000 millimeters in diameter at a cutting speed of up to 300 meters a minute. The weight of the lathe is about 25 tons.

A considerable increase in the production of precision instruments specified in the postwar Five-Year Plan has necessitated the development of a special base for the production of machine tools for precision-machine and instrument building in the USSR.

Numerous technical difficulties were encountered in this endeavor. The manufacture of high-precision machine tools involves the solution of complex technological problems, the use of materials of special quality, high-precision antifriction bearings, high-quality electric motors, optics, etc.

Despite the difficulties in mastering the production of high-precision machine tools, in 1949, Soviet industry had supplied the national economy with the Model 2450 jig boring machine, 600 x 1,100 millimeters in size, the MM582 thread-grinding machine for machining parts 100 millimeters in diameter and 700 millimeters long, the Model 3816 finishing machine for mirror-surface finishing of cylindrical roller bearings, and the Model 345 spline grinder for machining shafts up to 120 millimeters in diameter and 750 millimeters long, etc.

A special place is occupied by precision machine tools for machining precision lead screws for lathes and other machines, as well as dividing pairs (para) for gear-cutting machines. The variety of types of grinding and jig boring machines for tool production has greatly expanded. The production of gear-grinding machines, small precision lathes, milling, gear-cutting, and other machines for precision-machine and instrument building is being perfected.

In describing the technical progress in machine-tool building, it is impossible not to dwell, however briefly, on the development of those branches of industry closely connected with machine-tool production on which depends the further development of machine-tool building. This refers first of all to industries producing tools, abrasives, electrical and hydraulic equipment, fittings, standard and conventional parts, etc.

In prerevolutionary Russia only the simplest, predominantly forged tools were made, 90 percent of the required tools being imported from abroad. An abrasives industry was completely lacking. The only plant in the whole country was a semidomestic one which produced only rough grinding wheels out of raw materials imported from Germany.

After the October Revolution, and especially during the earlier Five-Year Plans, simultaneously with the development of the machine-tool-building industry, an intensive development of tool and abrasives production took place. During the first two Stalin Five-Year Plans, nine special tool-making plants were set up. In the course of just 12 years, from 1928 to 1940, the output of the tool industry increased six times. As a result of the Stalin Five-Year Plans, a powerful tool base was developed, capable of manufacturing any kind of tool and making the Soviet Union independent of foreign sources. Great forward strides have been made by the tool industry during the postwar Five-Year Plan.

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On the basis of the experience of innovators in high-speed machining and the perfection of high-speed machine-tool production, the tool industry was confronted with the task of expanding the production of hard-alloy cutting tools which will make it possible to machine heat-treated and very hard steels and to reduce the machining time three to five times.

In 1949, a considerable expansion in the number of types of hard-alloy tools, including drills, counter bores, reamers, and face-, side-, and end-milling cutters took place. Production of hard-alloy tools increased 2.5 times in 1949, as compared with 1948.

Series production of gear-cutting tools was perfected. These tools include hobs with inserted blades, large-module milling cutters, Class A hobs with flanking profile and precision-made for precision machine building; hobs, slotting, and shaving tools with modules of 0.1-1 millimeters, to be used in instrument building; thread-cutting and boring tools for the machining of geological-prospecting pipes up to 16 inches in diameter; and the 3KA and 4KA thread-cutting heads for automatics.

A number of measuring-tool plants have perfected and are now producing the following: a series of complex checking automatics for piston rings and ball bearings, a series of electrical multimeasuring instruments of the signal-light type, pneumatic two-tube instruments, instruments for checking the backlash of small-module gears with minimeters of new design, and checking and sorting automatics.

The production of abrasives has increased every year. During the earlier Stalin Five-Year Plans, production of grinding wheels was 90 times that of the prerevolutionary period. To replace the semidomestic industry, a modern abrasives industry developed, with widely mechanized working processes, capable of meeting the demands of the national economy for abrasive products of any hardness and form.

The great expansion in production of new types of abrasives and allied materials during the postwar Five-Year Plan is bound up with the widespread adoption of the hard-alloy cutting tools. In 1949 alone, Soviet industry received 94 new types of abrasive tools of improved quality, which permitted an increase in labor productivity and provided highly productive tools for new technological operations.

As a result of the creative efforts of the personnel of the Scientific Research Institute for Abrasives and Grinding in the period 1948 - 1949, for the first time in history, a special abrasive tool, supplanting expensive diamonds was developed for truing grinding wheels. This achievement was awarded a Stalin Prize for 1949.

To insure high-quality machine-tool equipment and considerable reduction in production cost in the machine-tool-building industry, ancillary industries were developed for the manufacture of hydraulic and electrical equipment, machine-tool accessories, and standardized parts. As a result of the centralized supply of fastening and reinforcing parts manufactured at specialized auxiliary enterprises, one of the milling-machine plants was able to save one million rubles a year.

By supplying the national economy with highly productive equipment, machine-tool building has facilitated technical progress in a number of leading branches of machine building. Automatic-transfer machine lines for the automobile, tractor, and agricultural-machine-building industries, and machine

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tools for locomotive, railroad car, metallurgical, petroleum, turbine, and other branches of industry have greatly increased production in all these fields and made it possible to organize constant-flow production of highly labor-consuming operations in machine building.

Close collaboration of machine-tool builders with these branches, and especially with the automobile and tractor industry, has resulted in their mutual enrichment through the exchange of advanced techniques. Studying the methods of mass production of automobiles, tractors, and other machines, machine-tool builders began to adopt these methods at their own plants.

For the first time in the world in machine-tool building, output of DIP-200 lathes at the Krasnyy Proletariy Plant, and of Model 1615 lathes at the Volzhskiy Plant was converted to constant-flow methods of production, with the use of conveyers for assembly. In 1949, the Krasnyy Proletariy Plant, without production, switched over to the constant-flow method of production of the modernized high-speed 1A62 lathe, while the Volzhskiy Plant converted production of the 1615M lathe to the constant-flow method.

At present, more than 90 percent of the lathes capable of machining diameters of 320-400 millimeters are being produced by constant-flow methods at the ministry's plants. As a result, labor consumption in the production of machine tools has been cut 25-30 percent while their output has increased 40-50 percent.

Also for the first time in the world in the tool industry, constant-flow production has been organized, employing conveyers not only in assembly but also in the machining of micrometers and slide gauges at the Kalibr Plant; of dies and taps at the Frezer, Gestroretzsk, and other plants, and of segments for circular saws at the Kirzhach Plant.

A large quantity of tools is now produced by the conveyer method: micrometers, 90 percent; slide gauges, 90 percent; segments, 100 percent; indicators, 95 percent; slotting cutters, 80 percent; and files, 55 percent.

In 1949, constant-flow lines for the manufacture of bakelite-bonded grinding wheels went into operation at abrasives plants. This made possible an annual increase of 400 tons in grinding-wheel production and a 15-percent decrease in labor consumption.

In foundry production, constant-flow methods of casting on conveyers are being employed; at the same time new molding and core materials of readily available raw materials are being perfected.

In 1949, 76 percent more constant-flow lines and technologically closed sections were organized than in 1948.

High-speed work methods have received most extensive dissemination in the ministry's plants. There are already thousands of high-speed innovators. Cutting speeds of 600-700 meters per minute are no longer news at machine-tool building plants; some high-speed workers have attained cutting speeds of 1,500-2,000 meters per minute. In 1949, 61 percent more machine tools were converted to high-speed cutting than in 1948.

The high-speed movement entered a newer, more advanced stage in 1949. Entire sections and wings employing high-speed methods of machining appeared.

The progressive technological processes adopted by the machine-tool-building industry have necessitated the designing, perfection, and introduction of new highly productive machine-tools. Before the war, the machine-tool-building

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industry did not utilize combination boring, multispindle, and other special machines. Now, the technology of constant-flow production is based principally on these machine tools. The basic parts of lathes such as head stocks and tailstocks, aprons, and feed boxes are machined primarily on combination machine tools. This shortens machining time six to ten times.

Machining on multicutter machine tools with an automatic operating cycle and multispindle milling of the surfaces of such basic parts as beds, headstocks, carriages, etc., are now common.

In the production of fitting and assembly tools, three-jaw chucks, files, and machine-tool parts, external broaching is employed, which increases productivity two or three times.

In 1949, plants of the ministry widely adopted the vortical method of worm-gear and screw cutting, which increases the productivity of cutting three to five times. Hardening of lathe-bed ways by high-frequency currents was perfected. This increases their wear resistance several times. The technology of series production of sectional hobs and side-milling cutters with pressed-in (zapressovanny) blades has been mastered. This has meant a great saving in high-speed steel.

In 1949, machine molding in the foundries of machine-tool-building plants increased 22.5 percent over that of 1948. There has been an increase in centrifugal chill casting. The precision casting of tools and parts of complex shape has been mastered. The heating of air blasts in cupola furnaces has been introduced to save fuel. Modified pig iron, which increases the durability and wear resistance of basic machine-tool parts, has also been adopted.

Technological improvements at abrasives plants have resulted in increased output of abrasive wheels, in better quality, more uniform hardness, and improved production of abrasive grains of particularly needed sizes.

At machine-tool-building and tool plants, widespread automatization of production processes is taking place.

No less general is the mechanization of labor-consuming and arduous operations, especially in foundries in machine-tool-building plants.

The preparation of sand, its distribution to work areas, and the loading of machines were previously done manually; now, all these processes are mechanized at the basic plants of the ministry. Central mechanized sand-conditioning machines have been developed, which raise productivity two or three times.

IV. THE ROLE OF SCIENCE IN THE DEVELOPMENT OF SOVIET MACHINE-TOOL BUILDING

One of the distinguishing features of Soviet technique is the creation of conditions favorable to the broad development of scientific research work. It is not by accident that in 1933, the great Experimental Scientific Research Institute of Metal-Cutting Machine-Tools (ENIMS), the first in the world, was established in the USSR. Soviet machine-tool building now has at its disposal a highly developed network of scientific research organizations. During the 17 years of its activity, ENIMS has created many first-class types of machine tools. Under the leadership of V. I. Dikushin, its chief designer, Stalin

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Prize winner, and corresponding member of the Academy of Sciences USSR, ENIMS has developed and widely introduced into domestic machine building combination machine tools, automatic-transfer machine lines and the automatic-piston plant.

Experimental checking of the operational qualities of various parts and units, as well as of machine tools as a whole, which is being carried on by ENIMS, permits the solution of the problems of selecting the best materials, shapes, and designs for machine tools. For the first time in the world, in machine-building practice, ENIMS scientifically worked out the problems of rigidity and vibration resistance in machine tools, which are of major importance in designing high-precision, long-lasting lathes.

The ENIMS staff worked out the basic theories of hydraulic drives for machine tools, which resulted in widespread incorporation of hydraulics into metal-cutting equipment by the domestic machine-tool-building industry.

One important task of ENIMS is the solution of problems concerning the design and use of electric drives for machine tools. During the earlier years of the postwar Five-Year Plan, ENIMS designed the ELIR electronic-ionic speed regulator for smooth adjustment of direct-current motors. The ELIR is far superior to analogous designs of US manufacture.

The work of ENIMS in the field of standardization and normalization has led to the circulation of several hundred departmental standards for parts and units in the machine-tool-building industry. With the use of these standards, the design and perfection of new machine tools are proceeding at a much faster rate. The broad development of standardization in the field of machine-tool building is spreading to other branches of industry. At present, departmental standards of machine-tool building are being used in organizations of more than 20 industrial ministries.

Problems concerning the automatization of production worked out by ENIMS are being developed further. On the basis of advanced soviet science, the ENIMS is conducting work on the systematic automatization of the most labor-consuming metalworking processes. Its work in the field of complex automatization of manufacturing processes is evidenced by the development of the automatic-piston plant and of lines for the manufacture of files, electric-motor shafts, and piston rings.

Besides developing new machine-tool designs for high-speed metalworking, ENIMS, during the postwar years, has done much work on the modernization of the existing machine-tool park, as a result of which Soviet industry has been shown some concrete methods of utilizing existing equipment for work at higher speed.

Results of the work of the All-Union Scientific Research Tool Institute (VNII) have made it possible to achieve cutting speeds of 450 meters per minute and higher through the use of hard-alloy-tipped cutting tools. On the basis of VNII research, the most economical and most productive domestic grades of hard alloy were determined. These are now used for high-speed milling.

The Scientific Research Bureau of Interchangeability, which was organized more than 15 years ago, has developed automatics for checking and sorting the automobile pistons made by the automatic plant.

[Innovators and leaders in Soviet machine-tool building who have been awarded Stalin Prizes for notable achievements are mentioned here. This information is available in FDD Summary No 25, 14 June 1950, and No 46, 18 June 1951.]

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V. IMMEDIATE PROBLEMS AND TECHNICAL TRENDS
IN SOVIET MACHINE-TOOL BUILDING

New machine-tool designs, their quality and wide variety of types, are leading to a radical change in technology, not only in machine building in general but also in a number of other branches of the national economy. Newer, more modern technological processes are increasing the rate of industrial development, raising labor productivity, and lowering production cost.

The development of Soviet machine-tool building in the immediate future will be characterized by the following basic principles:

1. Creation of high-quality, heavy, and unique machine tools, the design of which should provide:
 - a. Sharp reduction in auxiliary time for setting up heavy workpieces by the use of special installation devices and instruments.
 - b. Utilization of a considerable number of simultaneously working tools.
 - c. High-speed machining with the use of hard-alloy tools.
 - d. Maximum automatization of control and automatic interlocking as protection against breakdowns.
 - e. Maintenance of uniform, economical cutting speed in turning the faces of large-size parts.
 - f. Automatic chip removal.
 - g. Use of remote automatic control of the machine tool.
 - h. Automatization of the measurement of the workpiece during the machining process.
2. The design of special combination machine tools and automatic-transfer machine lines should provide maximum automatization of machining processes, automatic control of tool and machine operations, as well as the quality control of the size of workpieces. The physical labor of workers on special and combination machine tools and automatic lines should be reduced to a minimum.
3. The next 3 years must see the perfection of various types of precision machine tools needed in connection with the technical development of the numerous branches of machine building which require a sharp increase in the precision of machined parts and machines as a whole.
4. New designs for general-purpose universal machine tools should provide a further increase in cutting speeds, utilization of the potentialities of hard-alloy tools, and precision and finish of machining. In the final analysis, these measures should result in increased labor productivity, lower labor consumption, and lower production cost.

For example, all types of milling machines should provide cutting speeds of 1,000 or more meters per minute.

The use of various types of automatic clamping devices will permit the widespread adoption of the practice of attending several machine tools at one time.

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A special place will be occupied by gear-processing machines. The existing variety of types of gear-processing machines is entirely inadequate. At present, measures are being taken to perfect a wide variety of gear-processing machines. Provision is being made for the development of a series (gamma) of gear-processing machines for precision-machine building and heavy-machine building, with work diameter of gear wheels up to 5,000 millimeters. Also envisaged are a series of gear-cutting machines for bevel gears up to 1,500 millimeters in diameter and a series of gear-finishing machines, including gear-grinding machines. Along with this, work is being conducted on the development of a more highly productive gear-processing tool.

For the first time in the Soviet Union, gear-processing machines for the manufacture of globoid meshing gears will be produced. These gears are indispensable in the manufacture and repair of blooming mills, slab mills, various types of rolling mills, and shears, the gear meshes of which show a high degree of technical development and require an extremely complex and fine technology of manufacture. The operating cycle of all the gear-processing machines is to be either automatic or semiautomatic.

Several type-sizes of heavy boring machines with spindle diameters up to 200 millimeters are being perfected. These are badly needed in heavy machine-tool building.

5. Future development in the tool and abrasives industries should bring their technical level up to the high standing of the machine-tool-building industry. For the tool industry, this means the development of all the required type-designations of highly productive hard-alloy cutting tools, various kinds of measuring apparatus, measuring automatics, and universal measuring tools. For the abrasives industry, it means the development of the type-designations of abrasive tools which will increase the productivity of grinding and other finishing machines and ensure precision and high-quality finish of machining.

6. In the field of new technology, it will be necessary:

a. To increase the number of constant-flow lines in the production of machine tools, tools, abrasives, and products of ancillary industries.

b. To convert completely to constant-flow production of slide gauges, cutters, drill chucks, files, round dies, blades for sectional tools, drills, taps, lathe chucks 240 and 325 millimeters in diameter, individual lighting equipment for machine tools, and grinding wheels for sharpening saws and hard-alloy tools;

c. To convert an overwhelming number of machine tools to high-speed machining methods.

d. To increase several times the number of high-speed sections.

e. To convert a number of plants to nonabrasive grinding of hard-alloy tools and to broaden the adoption of bimetallic parts and induction hardening of parts.

f. To introduce automatic regulation of the fusion of white corundum in electric furnaces, automatic air blast feed regulation in cupola furnaces, and automatics for checking and sorting drills and taps in constant-flow production.

g. To introduce wide-scale automatization of production processes by putting into operation the maximum number of automatics and semiautomatics, combination and special machine tools and automatic-transfer machine lines.

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